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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/522,832	03/10/2000	Katsuhisa Sawazaki	PMS 257760	4821

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EXAMINER

BAUMEISTER, BRADLEY W

ART UNIT

PAPER NUMBER

2815

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.
09/522,832

Applicant(s)
Sawazaki et al.

Examiner
B. William Baumeister

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on Jan 16, 2003
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1 and 4-15 is/are pending in the application.
- 4a) Of the above, claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1 and 4-15 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some* c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
*See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s). _____ 6) ☐ Other:

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DETAILED ACTION

Claim Rejections - 35 USC § 102

1. The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.
2. Claims 1, 4-6, 9 and 15 are rejected under 35 U.S.C. 102(e) as being anticipated by Nakamura et al. '307.
 - a. Regarding claims 1, 4-6 and 15 the rejection is based on the reasons set forth in the previous Office Actions which are incorporated hereinto. Applicant has amended claim 1 to further recite that the n-clad and the active layer's barriers have substantially the same bandgap. Claim 15 is substantially the same as claim 1, except that claim 15 is broader in that it does not set forth thickness limitations for the n-clad layer.
 - i. Applicant now argues that the condition of the barrier and clad being "substantially the same" means that the two respective layers are both composed of the same material and both have the same doping levels, and therefore they both have the same bandgap (REMARKS, page 4).
 - ii. The Examiner notes that Applicant has previously argued a different position that "substantially the same" means that the n-type clad layer and the barrier layer are composed of the same material, *but may be doped differently.*" (REMARKS associated with Amendment B, paper #10, filed 11/29/2001, page 3, last paragraph, italics added) As such, the

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assertion that the express claim language “substantially the same” necessarily implies that the doping levels are also the same, is refuted by Applicant’s earlier position. Thus, while Nakamura does disclose that the barriers and wells of the active layer may preferably be doped n-type to lower the threshold current (col. 6, lines 54-65), the claims as presently written do not require that the respective doping levels be the same, nor require resolutions of associated issues, such as (1) what objective range of doping concentration deviations constitute being “the same concentration level;” (2) whether Nakamura teaches “the same doping concentrations” which depends upon resolution of the first issue (also, see col. 10, lines 28-37 setting forth doping levels for n-layer 201; and col. 16, Example 6, setting forth one example of n-type doping concentrations for the active layer); (3) alternatively, whether it would have at least been obvious to set the respective doping levels to be “the same” in light of Nakamura’s disclosure; or (4) whether the portion of the specification reciting that the layers are grown under the same conditions supports a new claim recitation that the doping levels are the same or whether such claim language would constitute new matter (under either of the theories that “the same condition” in the specification (1) only refers to the base composition conditions but not to the doping conditions; or (2) that “the same condition” means that they are both the same composition and are both n-doped generally, but does not require that they be n-doped to the same concentration, both theories being supported by the fact that no particular doping levels are recited in the specification for either layer.

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iii. Applicant has further argued that because the respective doping concentrations are the same, the respective bandgaps therefore are also same. The Examiner notes for the record that altering a layer's base composition (e.g., changing from GaN to AlGaN) alters the bandgap. However, within the range of low to moderate doping levels (e.g., at doping levels that are less than up to at least $2E18$ which Applicant states in the specification is the doping level for the relatively higher doped contact layer 13: page 8, line 20), changing the doping concentration does not change the semiconductor's bandgap. Rather, shallow-impurity-doping shifts the Fermi level upward towards the conduction band (for n-dopants) or downward (for p-dopants). Restated, low to moderate n-doping shifts the entire bandgap downward relative to an undoped sample of the same material, but does not alter the width of the bandgap. As such, the newly added limitation that the clad and barrier have substantially the same band gap does not further limit the claims in that (1) the claims had already recited that they were composed of substantially the same material, and (2) the Examiner had already agreed to adopt Applicant's previous position that this term means that the two layers are composed of the same base composition (e.g., GaN). Thus, Applicant's subsequent arguments relating to the layers having the same bandgap have also been previously addressed in prior Office Actions and are incorporated herein, and have not been overcome for the reasons set forth herein and previously.

b. Regarding claim 9, the newly added claim further sets forth that the device further comprises a cap layer and a p-type clad layer formed on the cap layer. The Examiner notes that a "cap layer" may read on at least either one of (1) the active layer's uppermost barrier layer (see

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col. 6, lines 25- setting forth that the barrier layer may be the uppermost layer of the active region), or alternatively (2) the tunnel clad 101 (see e.g., FIG 5).

i. Regarding claim 9's recitation of the "p-type clad", the claim does not require that the clad be formed directly on the cap layer. As such, this element may be interpreted to read on the p-type clad 103 that is preferably made of AlGaIn within a thickness range of 10 nm to 2 microns (e.g, FIG 5 and col. 8, lines 43-50).

Claim Rejections - 35 USC § 103

3. Claims 8 and 10-14 are rejected under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Nakamura '307.

a. The claims are anticipated under the theory that all of the above-cited claims' ranges are either fully encompassed by or significantly overlap with the respective ranges set forth by Nakamura. Specifically:

i. Regarding claim 8, Nakamura discloses that the active layer wells' thicknesses are preferably between 5 and 70 Angstroms and that the barriers' are preferably between 5 and 150 Angstroms (col. 6, lines 45-53).

ii. Regarding claims 10-13, Nakamura discloses that the p-clad (layer 103) has a thickness which is within the range of 100 Angstroms to 2 microns (col. 8, lines 43-55). The barriers and wells of the MQW active layer may be dimensioned such that the device emits wavelengths within the range of 365 nm (UV) to 660 nm (red) (col. 6, lines 35-).

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iii. Regarding claim 14, Nakamura discloses that the p-clad 103 is preferably composed of $\text{In}_m\text{Al}_n\text{Ga}_{1-m-n}\text{N}$ ($0 \leq m \leq 1$, $0 < n \leq 1$, $0 < m+n \leq 1$) and preferably AlGaN. This formula's range encompasses the claimed range of Al being between 0.1 and 0.14.

b. The claims are alternatively rejected as being obvious over Nakamura due to the present split that exists in the Board of Patent Appeals member's positions on the issue of the anticipation of ranges. (See e.g., *Ex parte Lee* (BdPatApp&Int) 31 USPQ2d 1105 (1993).)

i. The claimed range limitations relating to the barrier and well thicknesses and the emitted wavelength ranges are fully encompassed by the ranges set forth in Nakamura. Further, it was well known to those of ordinary skill in the art at the time of the invention how the specific wavelength emitted depends on various factors such as the wells' and barriers' respective bandgaps (compositions) and thicknesses, as these factors influence the carriers' allowed states in the wells and therefore the MQW's effective bandgap. It was also well known how the respective lattice constants associated the particular materials affect the ability to grow heterojunction superlattices and the resultant strains which, in turn, may further influence the MQW's effective bandgap.

ii. Regarding the Al concentration of the p-AlGaN clad (claim 14), as was stated above, the claimed range was fully encompassed by the range set forth in Nakamura. Further, it was well known to the skilled artisan that increasing the Al content increases the effective bandgap and therefore the effective carrier confinement, but simultaneously increases the voltage requirements.

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iii. Regarding thicknesses of the p-clad, the 100A - 2 micron range disclosed by Nakamura fully encompasses the 240-360 angstrom and 120-300 angstrom ranges set forth in the green and blue emitters of claims 11 and 13, respectively, as well as the broader range set forth in the green emitter of claim 10, and it substantially overlaps all but the lowest end of the blue emitter's broader range set forth in claim 12. Further, in addition to increasing the associated manufacturing costs, Nakamura teaches that increasing the clad's thickness decreases the threshold current density (compare examples 9 and 10).

iv. Restated, even if the encompassing and overlapping ranges of Nakamura should be interpreted as not anticipating these claims, the claims' ranges do not produce any novel or unexpected results but rather relate to factors that were previously known and well understood by those skilled in the art at the time of the invention, and as such, merely constitute non-obvious design optimizations. *See e.g., In re Luck* 177 USPQ 523 (CCPA), holding that routine testing to ascertain the optimum amounts or the most favorable proportions of a compound to achieve its recognized effect would lie within the ambit of ordinary skill in the art.

4. Claim 7 is rejected under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Nakamura '307 as applied to the claims above. Claim 7 further recites that both the clad and the barrier are specifically composed of GaN.

a. Nakamura expressly states that the barrier layers of the MQB active region 16 may be composed of GaN (col. 6, line 29). While Nakamura states that it is *preferable* that layer 201

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is formed of an aluminum-containing nitride (AlGaN) (col. 10), the disclosure is not so limited. Rather, the reference also expressly states that the tunnel/barrier “layer 201 ... is formed of a nitride semiconductor layer having a band gap energy larger than that of the active layer 16 (more strictly, its well layer)” (col. 10, lines 10-); and it expressly states that layer 201 “has a band gap energy which is larger than that of the active layer by 0.01 - 4.05 eV” (e.g., col. 4, lines 20-21). Further, the bandgap difference between the GaN-based active layer’s barriers and wells would necessarily be greater than 0.01 eV; otherwise the active region would not be a superlattice, but would instead be a bulk semiconductor region. Restated, Nakamura’s teaching that the tunnel/barrier layer 201 can have a bandgap that is anywhere from 0.01 to 4.05 eV greater than that of the well (which, in turn, is less than that of either the effective or barrier layers’ bandgaps), is a teaching that the tunnel/barrier can have a band-gap energy that is either less than, the same as, or greater than that of the active layer’s GaN barrier. Moreover, this teaching that the bandgap of the tunnel/barrier may be the same as that of the active region’s barriers, is merely another way of saying that the two layers are composed of the same material; e.g., GaN.

b. Accordingly, since Nakamura teaches that active layer barrier may be GaN and the tunnel/barrier may be made of any bandgap(/composition) within a range that includes GaN, Nakamura anticipates the claim.

c. Alternatively, assuming arguendo that Nakamura must be interpreted so narrowly such that the disclosure of the range is not a disclosure (that the tunnel/barrier may also be composed of GaN) of sufficient particularity as to constitute a data point that would serve as the

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basis for a 102 anticipation rejection, the claim would nonetheless be obvious over Nakamura. This is because changing the bandgap(/composition) of the tunnel/barrier does not produce any unexpected results. Rather, such changes produce well understood and expected results: as the bandgap increases (as more Al is added to GaN), the tunnel/barrier becomes progressively more efficient in preventing carrier overflow, and the injection efficiency decreases somewhat relative to if no tunnel/barrier was present (because the tunneling probability is necessarily less than 1 and increasing the tunnel/barrier bandgap increases the proportion of carriers that are injected by tunneling). Conversely, as the bandgap decreases, (as the Al is decreased or as more In is added to GaN), the injection efficiency increases, but the tunnel/barrier becomes progressively less efficient in preventing carrier overflow from the opposite side of the active region. Also, increasing the thickness of a tunnel/barrier of any given bandgap decreases the tunneling probability.

d. Accordingly, since Nakamura teaches that active layer barrier may be GaN and the tunnel/barrier may be made of any bandgap/composition within a range that includes GaN, it would have been obvious to one of ordinary skill in the art at the time of the invention to make both the active region's barriers and the tunnel/barrier of GaN because this particular combination is within the range of possibilities disclosed by Nakamura, and one of ordinary skill would have been motivated to choose this particular combination depending only upon conventional and well understood considerations such as the desired light-emission wavelength of the MQB and the desired balance of the tradeoff between injection efficiency and carrier overflow of the particular

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application; or for various other reasons such as (1) because binary compounds (i.e., GaN) are more stable and easier to form than tertiary compounds (e.g., AlGaN or InGaN); or (2) for considerations of better lattice-matching of the tunnel/barrier to the adjacent MQB barrier since GaN has a lattice constant that is closer to the InGaN compositions than does any of the AlGaN compositions.

Response to Arguments

5. Applicant's arguments filed 7/8/02 and 9/4/02 have been fully considered but they are not persuasive for the reasons set forth previously, hereinabove and hereinbelow.

a. Applicant has again argued that making the tunnel/barrier composition the same as that of the barrier would be detrimental to the effect of blocking carrier overflow, which is the goal of Nakamura, and therefore, Nakamura does not teach that this relationship is disclosed. This argument is not convincing because while Nakamura is directed towards blocking carrier overflow, and further states that this is *preferably* accomplished by forming the tunnel/barrier of AlGaN, these facts do not detract from the additional fact that Nakamura also expressly teaches that preventing carrier overflow may be also accomplished by providing GaN-based tunnel/barriers that have any bandgap that is 0.1 eV or greater than that of the active layer's well (as opposed to either one of the higher barrier or effective bandgaps). Accordingly, the rejections are still deemed to be proper and therefore maintained.

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INFORMATION ON HOW TO CONTACT THE USPTO

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to the examiner, **B. William Baumeister**, at (703) 306-9165. The examiner can normally be reached Monday through Friday, 8:30 a.m. to 5:00 p.m. If the Examiner is not available, the Examiner's supervisor, Mr. Eddie Lee, can be reached at (703) 308-1690. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 308-0956.

A handwritten signature in black ink, appearing to read "B. William Baumeister". The signature is fluid and cursive, with a large initial "B" and a stylized "Baumeister".

B. William Baumeister

Patent Examiner, Art Unit 2815

February 8, 2003